Tutorial A

T-pipe junction CAD geometry

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Introduction

Background:

- This workshop assumes no prior experience of the FreeCAD modeling environment.

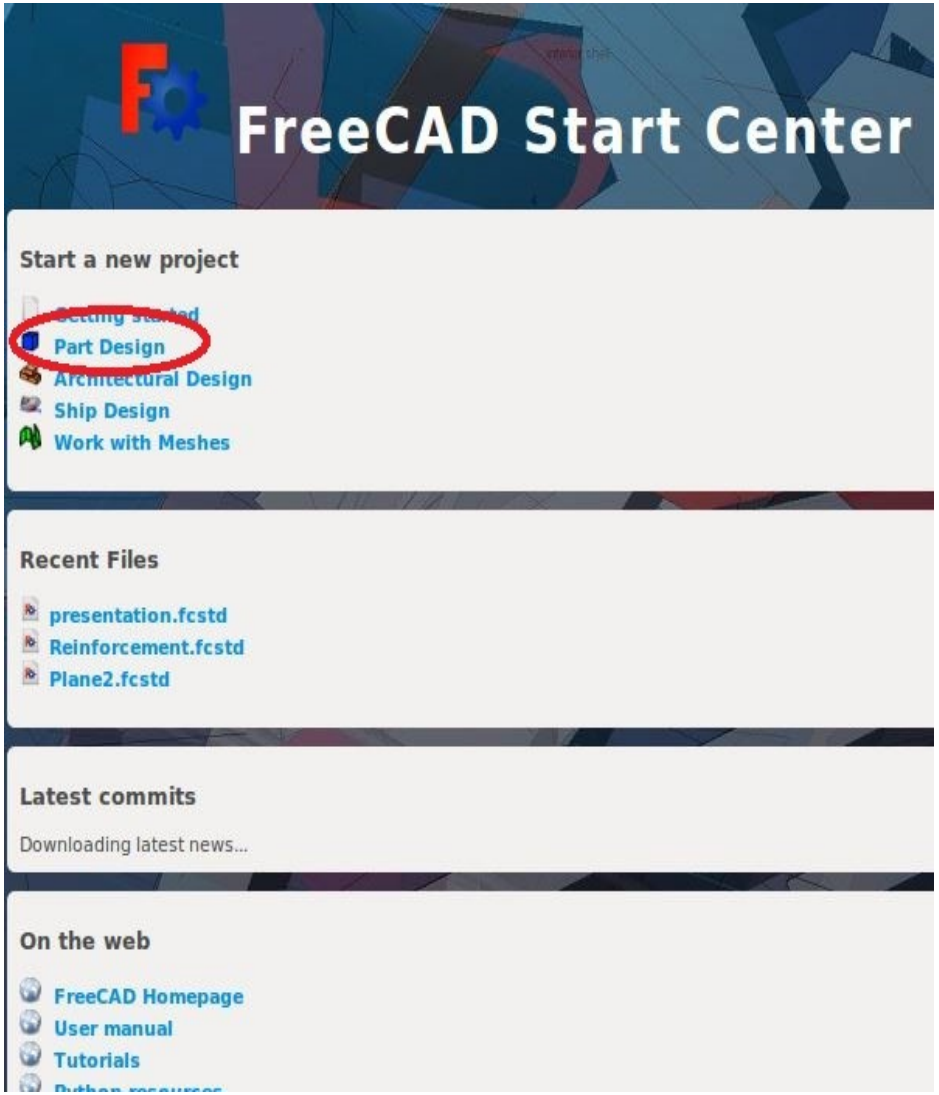
Objectives:

- Create a FreeCAD project
- Create T-pipe junction from sketches and basic 3D shapes in FreeCAD
- Use a design code to determine amount of reinforcement
- Add reinforcement to the T-pipe section

Project start Up

Create the Project:

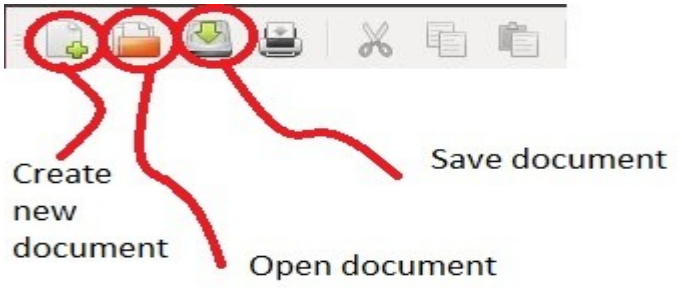
- Start FreeCAD
- Go to “Start a new project”
- Click on <Part Design>

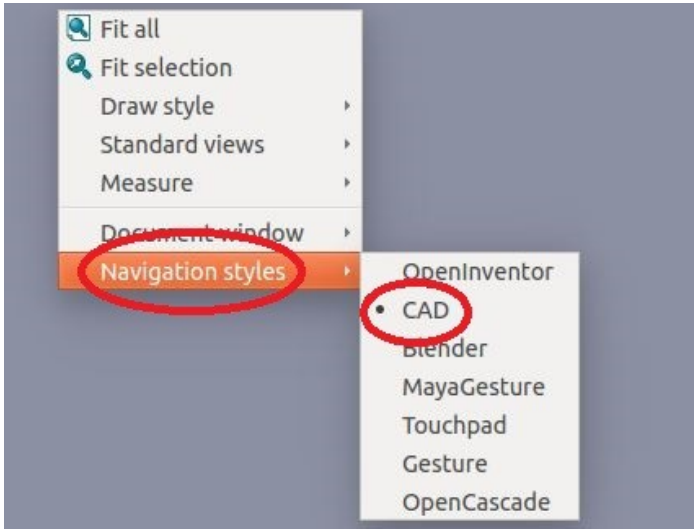


Project start Up

FreeCAD basic operations:

- This slide provides a basic introduction to the FreeCAD interface.
- The user can create, open and save projects.
- The user also has the ability to change and control the view displayed.
- The user has different navigation styles available, it is important to note that each navigation style has its own functionality and the user should familiarize themselves with the navigation style that best suits them. The tutorial is based on the navigation style “CAD”.

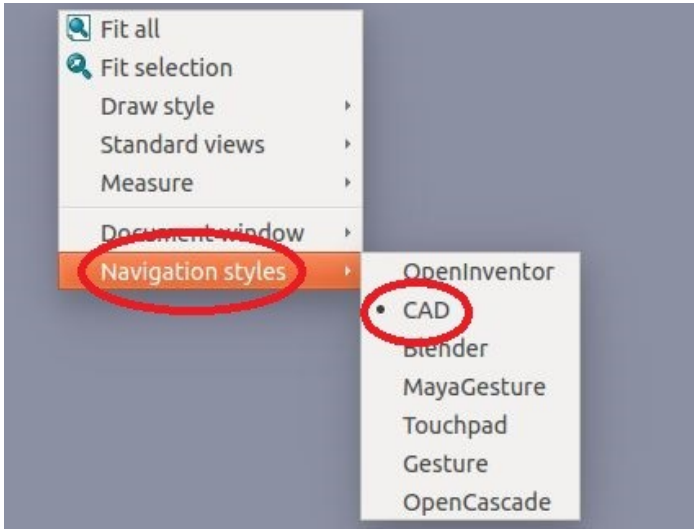




Project start Up

The CAD navigation style:

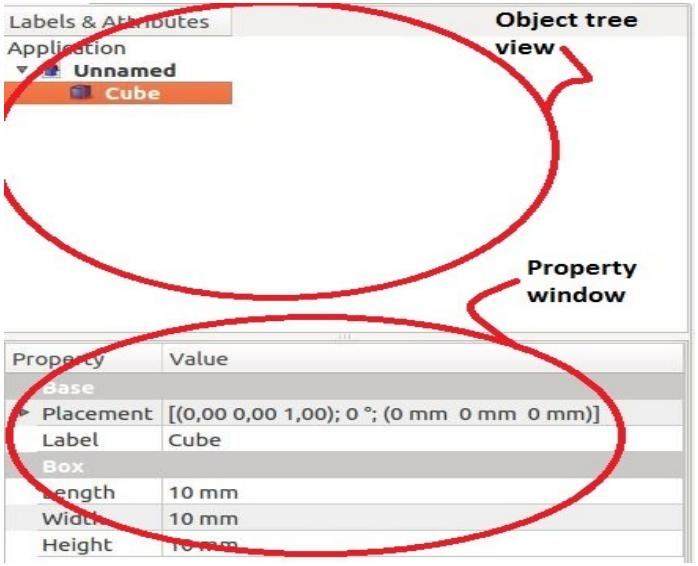
- In order to Zoom roll the Mouse Wheel
- In order to Pan hold the Mouse Wheel
- In order to Rotate hold the Mouse Wheel and the Left Mouse Button at the same time

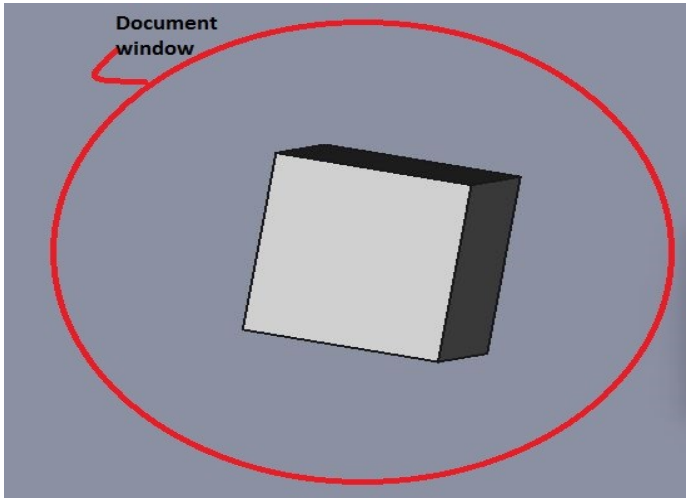


Project start Up

FreeCAD basic operations:

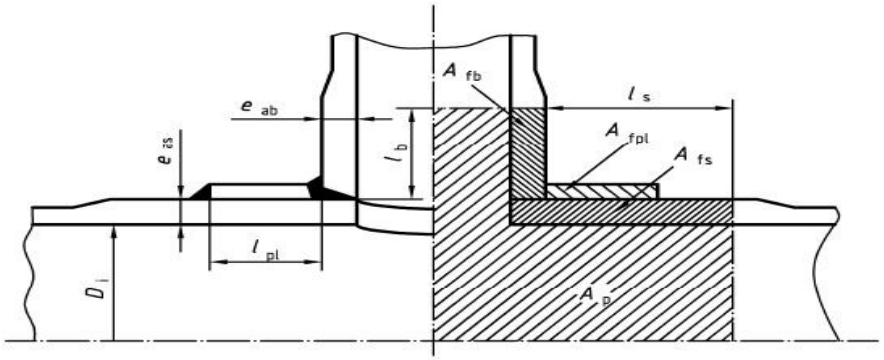
- The FreeCAD naming convention is introduced here as depicted in the pictures on the right.
- The document window is the entire area in the interface that displays the geometry.





Using a design code to determine reinforcement

Determining the amount reinforcement:



Parameters given:

$P_o = 9$ MPa, $T_o = 450°C$

$Material = 10\ CrMo\ 9-10$

$D_{os} = 300$ mm, $D_{is} = 250$ mm, $d_{ob} = 200$ mm, $d_{ib} = 170$ mm

$f_{pot} = 175.5$ MPa $(proof\ strength)$

b= branch, s =shell, pl = plate

From EN 13480-3:2012:

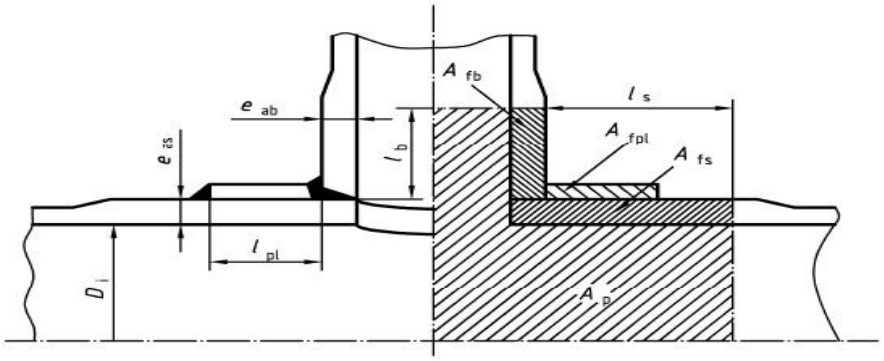
1. If then no reinforcement is required,
1. With $0.14\sqrt{D_{eqs}e_{as}} \geq d_{ib}$ then no reinforcement is required,

With $D_{eqs} = D_{is} + e_{as}$ $\therefore D_{eq} = 275$ mm and $0.14\sqrt{D_{eq}e_{as}} = 11.61$

$\therefore$ reinforcement is required

Using a design code to determine reinforcement

Determining the amount reinforcement:



2. Let $x = \left(f_s + \frac{p_c}{2}\right) A_{fs} + \left(f_b + \frac{p_c}{2}\right) A_{fb} + \left(f_{pl} + \frac{p_c}{2}\right) A_{fpl}$

3. $A_f = l \cdot e_a$

p_c = calculation pressure, f = design stress, $A_f = effective\ Area$

3. With and

2. With $p_c = P_{max} = 9$ MPa and $f_s = f_b = f_{pl} = \frac{R_{p0.2t}}{1.5} = 117$ MPa

4. If reinforcement is satisfactory

4. with $x \geq p_c A_p$ reinforcement is satisfactory

with $A_p = \left(l_s + \frac{d_o}{2}\right) D_i + (l_b + e_{as}) d_i$,

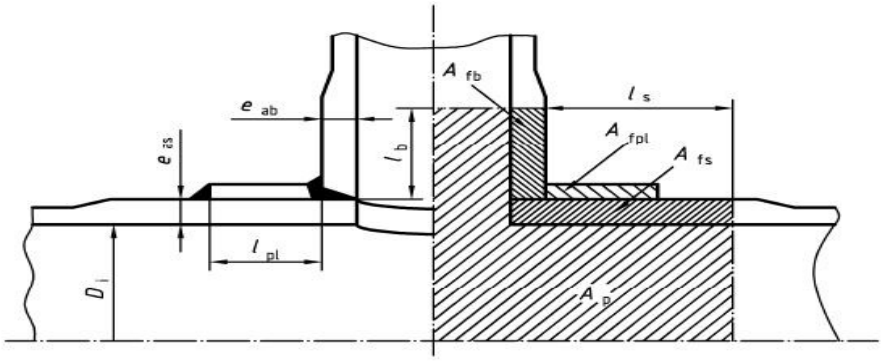
and

$l_s = \sqrt{D_{eqs} e_{as}}, l_b = \sqrt{d_{eqb} e_{ab}}$

and $l_{pl} \leq l_s, e_{apl} \leq e_{as}$

Using a design code to determine reinforcement

Determining the amount reinforcement:

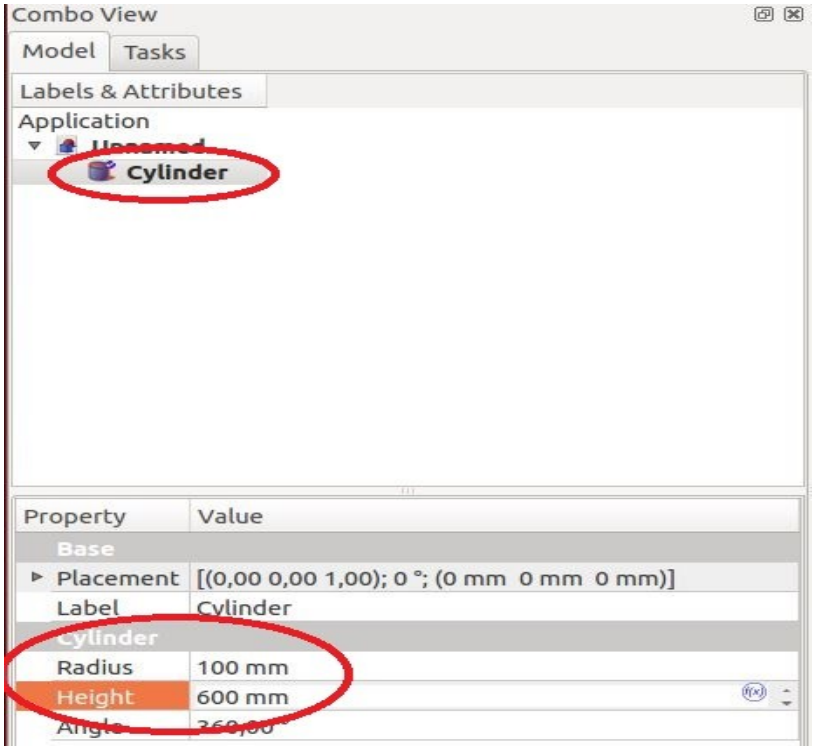


5. For $l_{pl} = 30$ mm, $l_s = 83$ mm , $l_b = 78$ mm
6. $e_{apl} = 25$ mm, $e_{as} = 25$ mm, $e_{ab} = 30$ mm
   (Increased branch thickness)
7. $p_c A_p = 569.34$ kN
8. $\therefore x = 586{,}69\text{kN} > p_c A_p$
   ∴ reinforcement is satisfactory
   ∴ adding reinforcement and increasing the branch pipe thickness is sufficient reinforcement for the T-pipe.

Create T-pipe junction CAD model

Create the branch pipe:

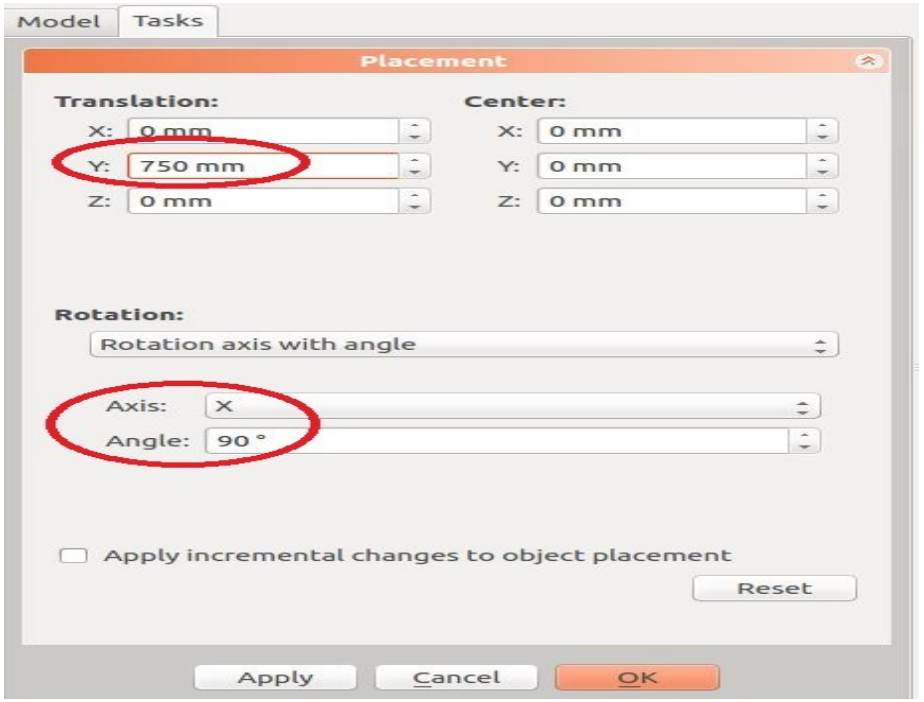
- Go to the Part workbench. Create a cylinder. To do so select the icon indicated in the picture. The user can also create other primitive shapes or combine this primitives shapes to create a new part.
- To change the cylinder dimensions, under “Combo view” select the Model tab. In this Model tab an object tree view is displayed with all the created objects. Click on <Cylinder> in the object tree view.
- In the property window, enter a cylinder radius of 100 mm and a cylinder height of 600 mm



Create T-pipe junction CAD model

Create the shell pipe:

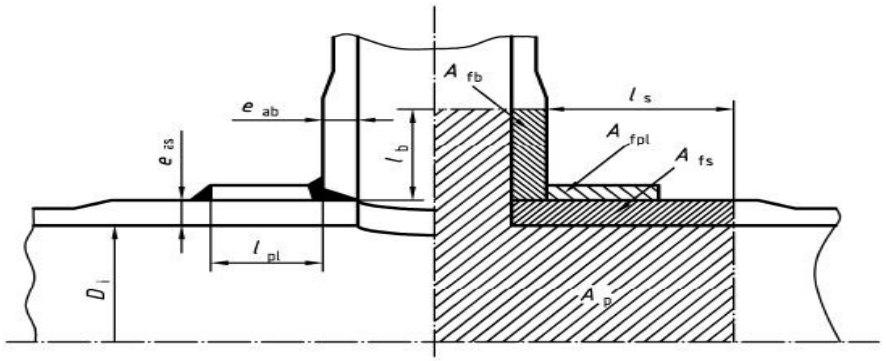
- Follow same steps used to create the first cylinder
- Enter a cylinder radius of 150 mm and a cylinder height of 1500 mm
- In the combo view under the Model tab, click on <Cylinder001> and then click on the ellipsis (more options) icon on “Placement”.
- A “Placement” task dialogue will appear and under “Translation” enter 750 in the Y direction. Enter rotation of 90°about the X axis and then click <Apply>

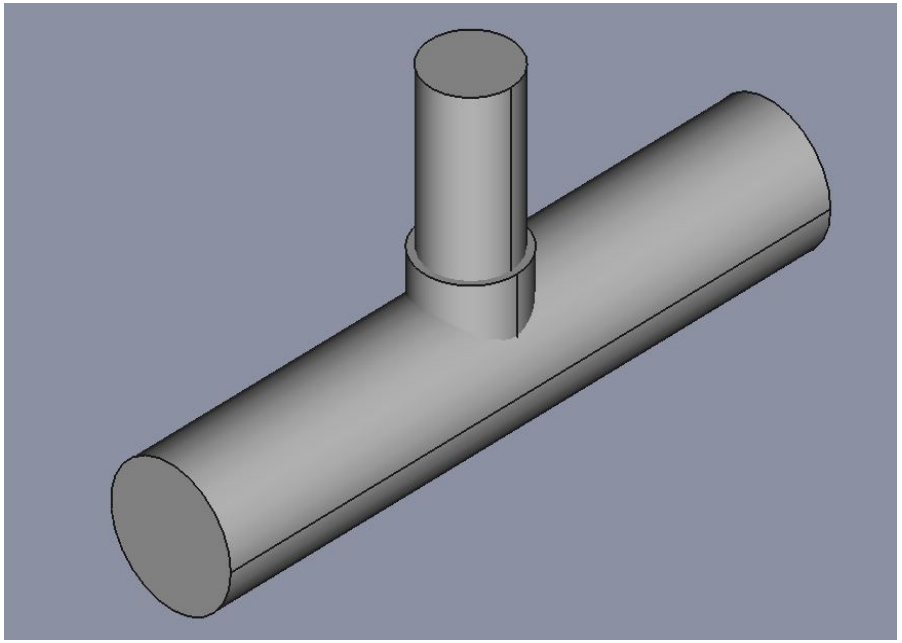


Create T-pipe junction CAD model

Increase the branch pipe thickness:

- The thickness of the branch pipe will be increased with a length of 78 mm from the shell pipe outer diameter
- Create a cylinder with a length 228 mm and a radius 115 mm
- The geometry in the document window should be similar to that indicated in the picture.

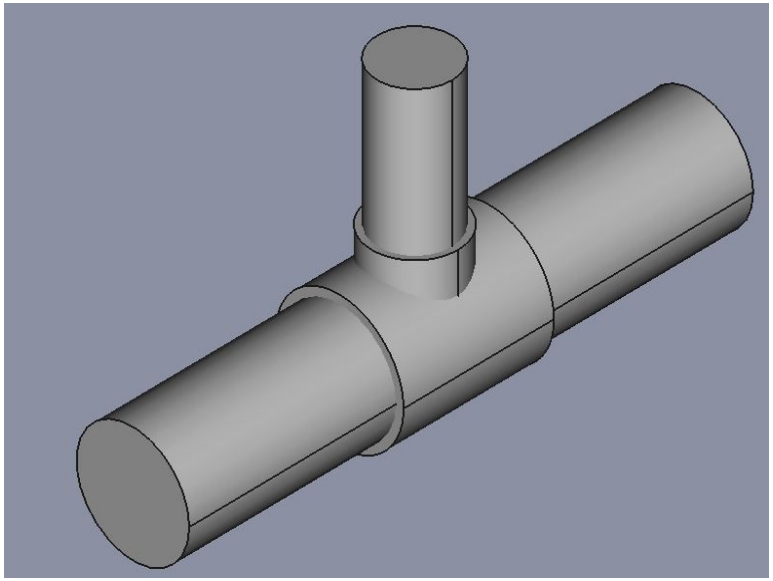


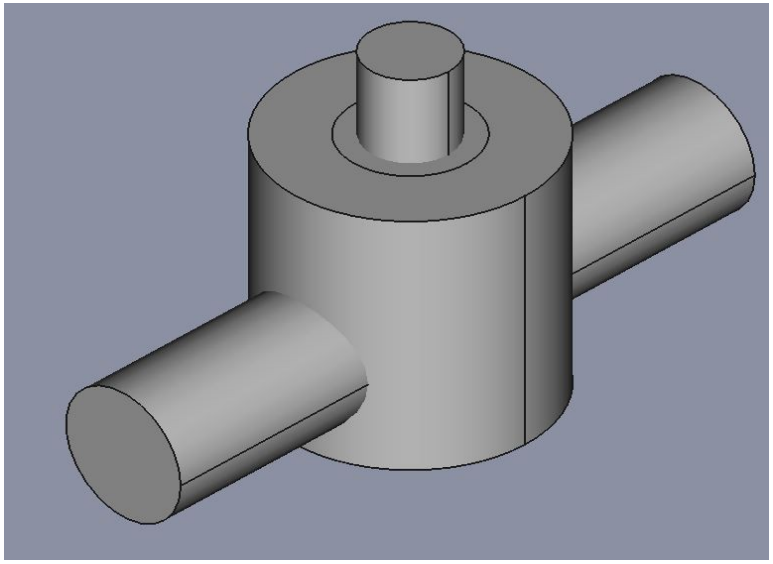


Create T-pipe junction CAD model

Add the reinforcement plate:

- The reinforcement plate is to have a thickness of 20 mm and an outer radius of 145 mm
- First create a cylinder with a length 400 mm and a radius 175 mm. Rotate this cylinder 90° about the X-axis and then translate it 200 mm in the Y-direction.
- Create two other cylinders with length 600 mm and radii 145 mm and 300 mm respectively. Translate both these cylinders 200 mm in the negative Z-direction.

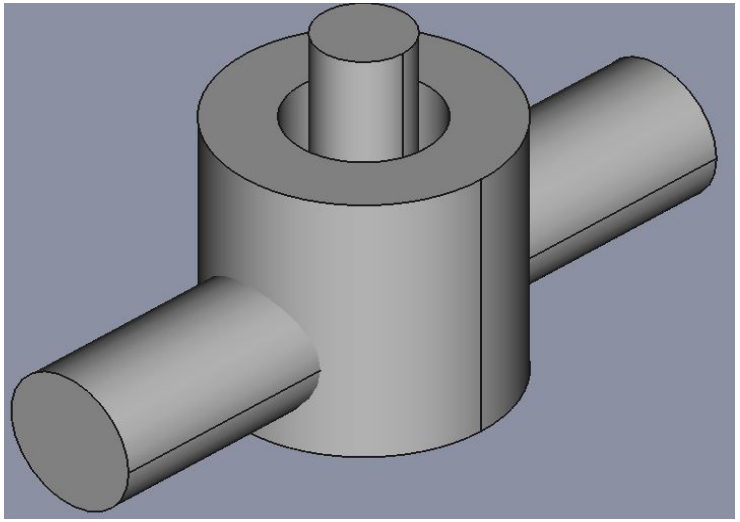


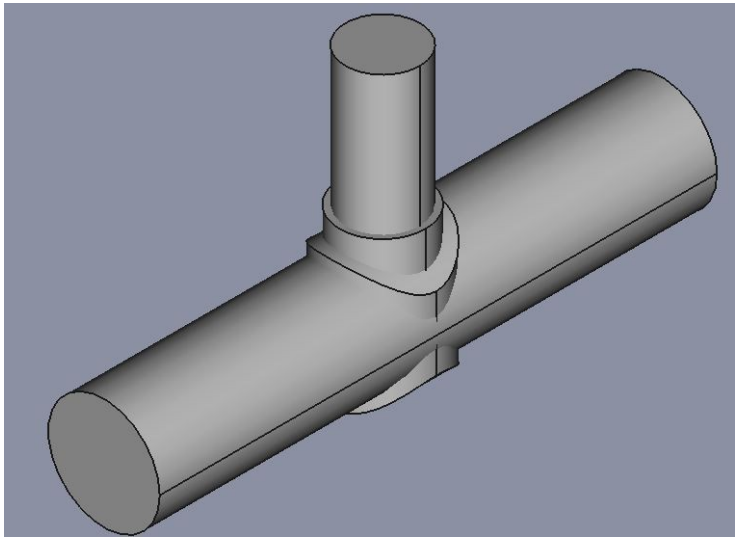


Create T-pipe junction CAD model

Add the reinforcement plate:

- Use the 145 mm radius cylinder to cut the 300 mm radius cylinder. To cut, first select the 300 mm radius cylinder and then the 145 mm radius cylinder.
- Now use this pipe to cut the 175 mm radius and 400 mm length cylinder by first selecting the 400 mm length cylinder and then the created pipe.

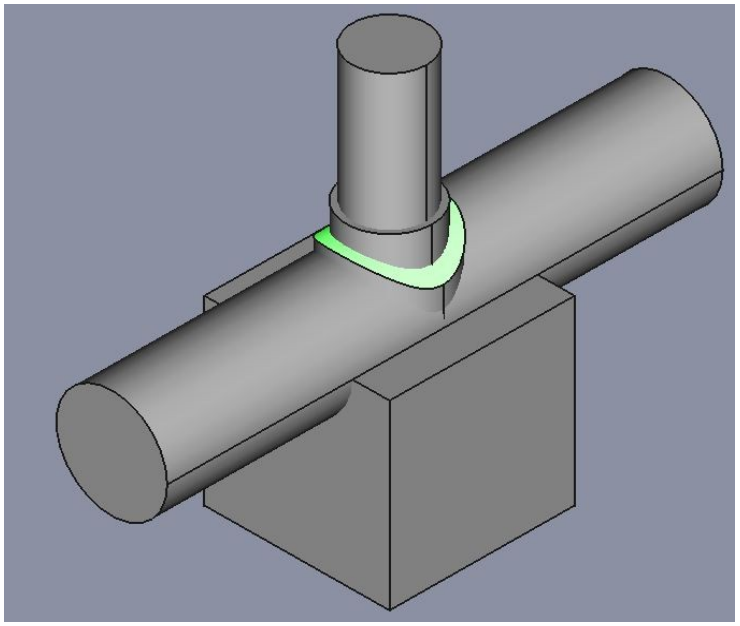


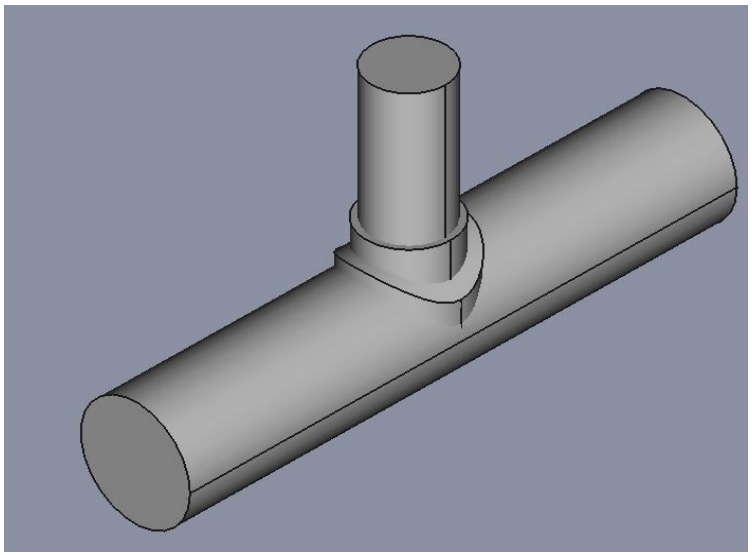


Create T-pipe junction CAD model

Add the reinforcement plate:

- Now to cut off the remaining piece of the plate at the bottom of the pipe.
- Create a cube with sides of 500 mm. Translate the cube 250 mm, 250 mm and 500 mm in the negative X, negative Y and negative Z directions respectively.
- In order to cut, first select the plate and then the created cube.

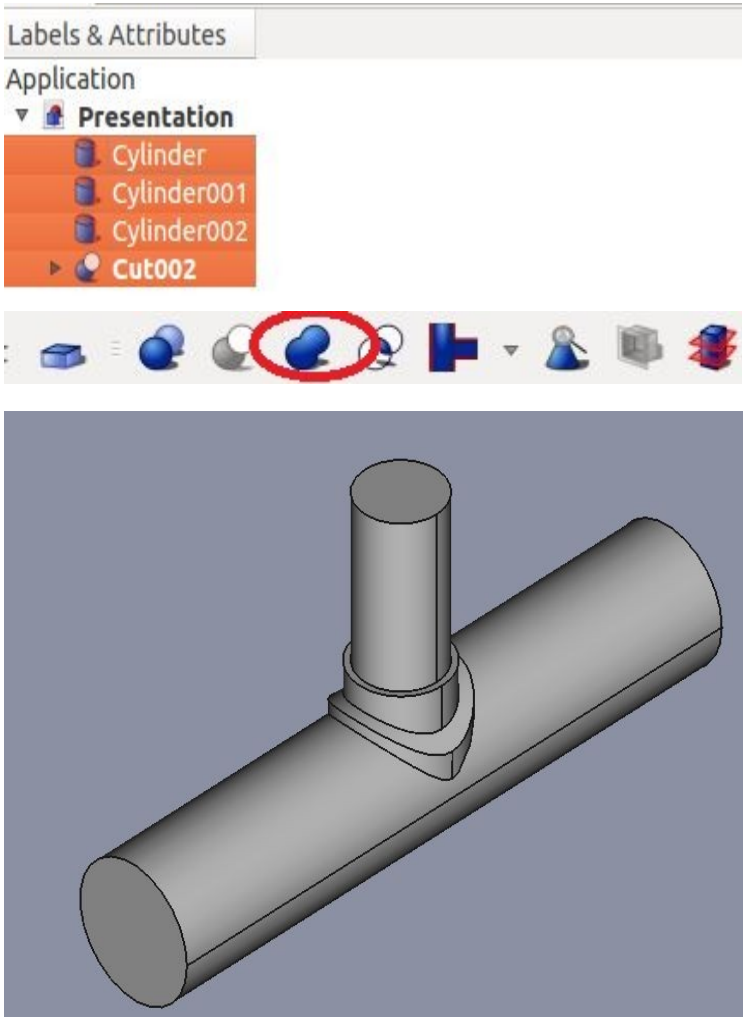




Create T-pipe junction CAD model

Add the reinforcement plate:

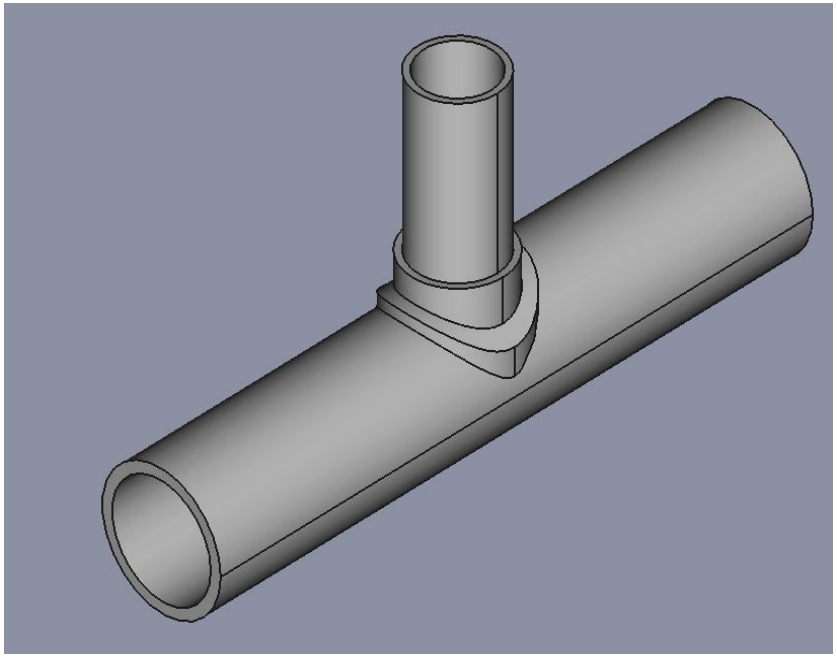
- Select all the parts in the object tree view and then click on <Make union of several shapes>
- The geometry should now be similar to that depicted in the picture.



Create T-pipe junction CAD model

Finishing off the T-pipe junction:

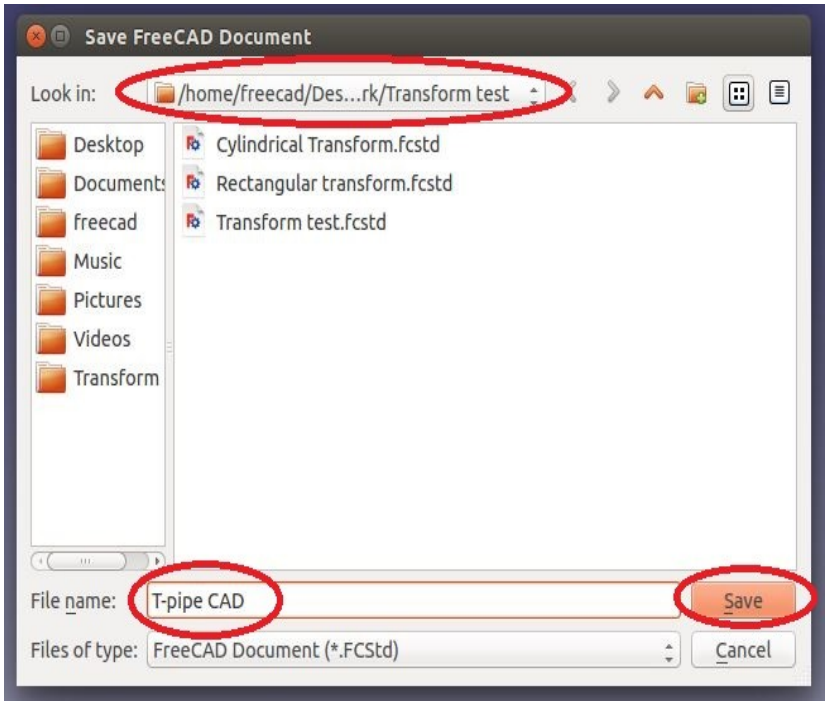
- Holes need to be made into the branch pipe and shell pipe.
- Create a cylinder with length 600 mm and radius 85 mm.
- Cut through the T-pipe with this created 85 mm radius cylinder.
- Create another cylinder with length 1500 mm and radius 125 mm. Rotate this cylinder 90° about the X-axis and then translate it 750 mm in the Y-direction.
- Cut through the T-pipe with this 125 mm radius cylinder

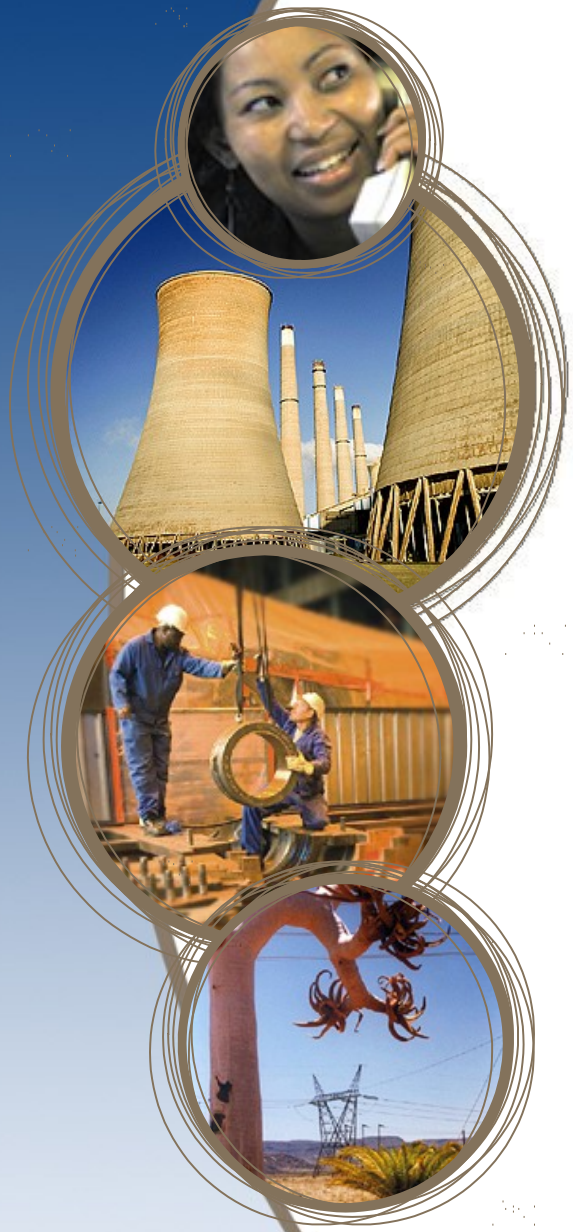


Create T-pipe junction CAD model

Saving the FreeCAD project:

- To save the project click on <Save the active document> as indicated in the picture.
- A task dialogue appears, choose the file directory, enter the file name and click <Save>.
- It is important to regularly save the project to avoid loss of work should any power interruptions occur.





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